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AUTHOR Neuwirth, Christine M.; And Others
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ABSTRACT

A 3-year project examined the cognitive effects of word processing on writing processes and products. In particular, the project examined effects on writers' planning, reviewing, and revising in a series of six assessment studies. Among the most important results of the project were that writers using word processing alone--both student writers and more experienced professional writers--engaged in significantly less initial planning, conceptual planning, and total planning than when they used pen and paper, and that this phenomenon was related to the difficulty experienced writers report in getting a "sense" of their texts and recalling them when using word processing. Findings of the project suggest that student writers be explicitly taught how to exploit the benefits and avoid the weaknesses of both word processing and pen and paper media. Results and recommendations of the project have been disseminated in a series of conference presentations, technical reports, and publications in national journals. (RS)

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ED329994

# Does word processing improve students' writing? A critical appraisal and assessment

## Final report to FIPSE

**Grantee organization:**

Carnegie Mellon University
English Department
Pittsburgh, PA 15213

**Grant number:**

G008642161-88

**Principal investigators:**

Christine M. Neuwirth
English Department
Carnegie Mellon University

Christina Haas
English Department
Carnegie Mellon University

John R. Hayes
Psychology Department
Carnegie Mellon University

**FIPSE program officer:**

Brian Lekander

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## Does word processing improve students' writing? A critical appraisal and assessment

## Project summary

This project examined the cognitive effects of word-processing on writing processes and products. In particular, we examined effects on writers' planning, reviewing and revising in a series of assessment studies. Among our most important findings are that writers using word processing alone--both student writers and more experienced professional writers--engaged in significantly less initial planning, conceptual planning, and total planning than when they used pen and paper, and that this phenomena was related to the difficulty experienced writers report in getting a "sense" of their texts and recalling them when using word-processing. As a result of our project, we recommend that student writers be explicitly taught how to exploit the benefits and avoid the weaknesses of both word processing and pen and paper media.

**Principal investigators:**

| | | |
|---|---|---|
| Christine M. Neuwirth | English Department | [412]-268-8702 |
| Christina Haas | English Department | [412]-268-6717 |
| John R. Hayes | Psychology Department | [412]-268-2803 |

Carnegie Mellon University
Pittsburgh, PA 15213

**Titles of reports:**

CMU-CECE-TR-4 *Word Processing as Decision-making: Writers' Choices of Writing Media.*

CMU-CECE-TR-5 *"Seeing it on the Screen Isn't Really Seeing It": Reading Problems of Writers Using Word Processing.*

CMU-CECE-TR-6 *How the Writing Medium Shapes the Writing Process: Effects of Word Processing on Planning.*

CMU-CECE-TR-9 *Understanding On-line Composition: Applying a Cognitive Model of Revision to Word Processing.*

CMU-CECE-TR-10 *Composing in Technological Contexts: A Study of Note-Making.*

CMU-CECE-TR-11 *A Sense of the Text: Problems Writers Encounter in Building Text Representations.*

CMU-CECE-TR-12 *Theory and Research into Practice: Word Processing and Writing Instruction.*

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# 1. Executive summary

### Project overview

This project examined the cognitive effects of word-processing on writing processes and products. In particular, we examined effects on writers' planning, reviewing and revising in a series of six assessment studies. Among our most important findings are that writers using word processing alone--both student writers and more experienced professional writers--engaged in significantly less initial planning, conceptual planning and total planning than when they used pen and paper, and that this phenomena was related to the difficulty experienced writers report in getting a "sense" of their texts and recalling them when using word-processing. As a result of our project, we recommend that student writers be explicitly taught how to exploit the benefits and avoid the weaknesses of both word processing and pen and paper media. We have disseminated our results and recommendations in courses and in a series of conference presentations, technical reports and publications in national journals.

### Background and Purpose

This project set out to assess the cognitive effects of word-processing on student writers. At the time of the proposal, the possibility that word processing systems could radically improve both writing and the teaching of writing had been noted enthusiastically by many authors. The cause of this enthusiasm was easy to find: Word processing systems offer obvious advantages for certain writing functions such as text formatting, spell checking, and surface editing. It is also easy, though not necessarily justified, to extrapolate these advantages to writing as a whole.

When we began the project, only a handful of studies had attempted to validate such extrapolations and actually assess the effects of word processors on writing. We reviewed those studies and argued that the question "Does word processing improve students' writing?" is more problematic than it appears and more complex than most previous studies assumed. We argued that studies were needed to ask two questions: 1) under what circumstances does the word processor help writers or improve writing? and 2) are the benefits worth the costs?

We felt that until these questions were adequately addressed, school administrators would have little information on which to base decisions about crucial resource allocation issues. Likewise, writing

teachers would have little information on which to base decisions about the following crucial curriculum design issues: Is there a real, substantial benefit to my students for word processing or is their time better spent on other activities? Should I actually allocate part of my limited class time to teaching students how to compose effectively with a word processor? If some of my students are using word processing, what do I need to know about word processors so that I can teach them most effectively? What kinds of changes, if any, should I make to my course content and pedagogy so that students receive maximum benefits from the interaction between instruction in writing and word processing technology?

As institutions struggle with decisions about using computers to teach writing, we wanted to see them informed by reliable findings on the conditions that facilitate learning with computers.

## Project description

We conducted six studies on three of the component writing processes where we thought word processing would have a significant impact. The following are the component processes and the corresponding studies:

- **Planning**

  *Study 1. How Word Processing Affects Planning.* Examined planning process of experienced and student writers in three conditions: word processing alone, pen and paper, combination of word processing and pen and paper.

  *Study 2. Connecting process and product: A study of planning processes, text quality, and writing media.* Examined the complex relationship between writing media and planning processes, and judged quality of the content and organization of the resulting essays.

  *Study 3. Composing in Technological Contexts: A Study of Note-Making.* Analyzed note-making in writing and compared this activity across pen and paper and word processing conditions.

- **Reviewing**

  *Study 4. A Naturalistic Study of Computer Writers' Reading Problems.* Tracked six freshmen and five adult writers for the course of four months and examined the kinds of reading problems they had when using computers and how they used hard copy to supplement computer writing.

  *Study 5. A Sense of the Text: Problems Writers Encounter in Building Text Representations.* Examined how well writers understood their own texts, written with pen and paper or with word processing; also related this "sense of text" issue to planning processes.

- **Revision**

  *Study 6. Understanding On-line Revision.* Examined revising behaviors of expert and student writers in two conditions, word processing or pen and paper.

## Project results

*Study 1. How Word Processing Affects Planning.* Writers using word processing engaged in significantly less initial planning, conceptual planning and total planning than when they used pen and paper. The effects were similar for both student writers and more experienced professional writers. A third condition, in which writers used both media, showed no clear effects: writers used both media together in vastly different and very complex ways.

*Study 2. Connecting process and product: A study of planning processes, text quality, and writing media.* Two measures of planning showed no relationships with quality, while two did. Initial planning--planning before beginning to write--had no significant relationship with either measure of quality. Local planning--at the word- and sentence-level--similarly had no relationship (positive or negative) with text quality. However, total amount of planning was significantly related to organizational quality, although the relationship of total planning to combined quality was not significant. The most significant relationships

were found with conceptual planning, however. This kind of planning showed a significant relationship with organizational quality and was also related to combined quality scores. Although writers using word processing alone did significantly less total planning and conceptual planning, there were no significant differences between the quality of essays produced with word processors alone and those produced with pen and paper.

*Study 3. Composing in Technological Contexts: A Study of Note-Making.* Found that writers primarily made four kinds of notes: content notes, by far the most prevalent; structure notes, also common, in which writers made outlines or otherwise structured their ideas; emphasis notes, less frequent, in which writers highlighted or emphasized certain ideas; and procedural notes, quite rare, in which writers made notes to themselves about how to proceed. With word processing, writers tended to make content notes only, while with pen and paper they made a range of kinds of notes.

*Study 4. A Naturalistic Study of Computer Writers' Reading Problems.* This study used observational methods to study how computer writers use "hard copy" printouts of their texts. Eleven case study subjects were observed for four months. We found that writers use printouts primarily for reading, specifically, for four reading purposes: to check format, to proofread, to reorganize, and to gain "a sense of the text." There were differences across groups of writers, with student writers being more concerned with format and proofreading and experienced writers reading for all four purposes. Further, longer and more difficult tasks elicited more reading to reorganize and reading to gain a sense of the text.

*Study 5. A Sense of the Text: Problems Writers Encounter in Building Text Representations.* This study continued the examination of a problem that we began in Haas & Hayes (1986) and Study 3, above. In our interviews with numerous computer writers and in our study of computer writers' reading problems we frequently encountered what writers themselves often called "a problem getting a sense of the text." We found that writers recalled more of the main points of their essays when they were composing with pen and paper than with word processing. The results suggest that writers use of paper to supplement their computer writing is not simply a habit left-over from pre-computer training as many have speculated, but that it meets a real need that writers have to gain a sense of their own texts.

*Study 6. Understanding On-line Revision.* Found no effects for writing medium--pen and paper or word processor--in any of the analyses. In general, the experienced writers revised like experienced writers and the students, like students, regardless of condition. In measures of task definition, problem representation, and detection and correction of errors, the medium in which writers were working made little difference. While an effect of "no difference" is not particularly compelling, in this case it is very important. What this means is that we cannot expect that the word processor alone will make an appreciable difference in how writers revise. Sitting students down in front of computers and expecting their revision habits to change--as some authors have advocated--is simply not realistic.

We have disseminated these results through courses, a workshop at our national convention on writing, through conference presentations, technical reports and publications in national journals.

## Summary and conclusions

As a result of our studies, we believe that teachers should take active steps to insure that their students learn to use word processing effectively in composing. In particular, writing teachers with students who use word processing to compose should see that students:

- Plan with a combination of pen and paper and word processing, not word processing alone, or compensate for reduced planning with word processing alone by using an appropriate planning tool that prompts planning (Kozma, mss).
- Get frequent print-outs of drafts. A "paperless" writing curriculum should not be encouraged.

These recommendations have implications for administrators, who must insure that students have adequate access to printing facilities.

## 2. Project overview

Our project was driven by the need we, as writing educators, saw for a systematic exploration of the effects of computers on writing. Specifically, we set out to increase our understanding of how a common computer writing tool--word processing--effects the cognitive processes of writers. The project examined the cognitive effects of word-processing on writing processes and products. In particular, we examined effects on writers' planning, reviewing and revising in a series of six assessment studies. Among our most important findings are that writers using word processing alone--both student writers and more experienced professional writers--engaged in significantly less total planning, initial planning, and conceptual planning than when they used pen and paper and that this phenomena was related to the difficulty experienced writers report in getting a "sense" of their texts and recalling them when using word-processing. As a result of our project, we recommend that student writers be explicitly taught how to exploit the benefits and avoid the weaknesses of both word processing and pen and paper media. We have disseminated our results and recommendations in courses and in a series of conference presentations, technical reports and publications in national journals.

## 3. Background and purpose

As computers gain a prominent place in many college writing curricula, the need for assessment of their effects becomes important. Enthusiasm for the potential of computers to aid both writers and teachers of writing had driven early efforts to establish computer-based writing pedagogy and to examine the benefits of using computer tools for writing. Much of this early research and evaluation of computer writing tools had, we argued, serious drawbacks.

We saw our task, then, as one of systematically examining some of the effects of computer tools for writing in order to establish a firm research base which could support important pedagogical decisions about computers and writing. We limited our project to a study of word processing: not only is the word processor the most widely available and widely used computer tool for writing, but newer, more sophisticated tools--outlining programs, "idea" processors, and so forth--are often built around and upon basic word processing technology.

### 3.1. Our approach to assessment

Computers' "effects," of course, are not unitary and the technology's impact upon writing may be myriad: computers may change classroom dynamics and social relationships among writers and their subjects; computers may cause affective changes toward writing and learning; computers may bring about interesting and important changes in the form and substance of written products, or equally critical changes in the processes by which writing is produced. All of these potential areas of change are important ones to examine, but equally important in systematic studies of pedagogical questions is the need for a focused set of questions to pursue. Therefore, we limited our examination primarily to studies

of cognitive processes in writing and the effects that word processing technology may have on these processes. We believe that cognitive effects may be some of the most profound and wide-reaching of the many types of effects to accrue from the use of technology in writing.

The goal of our project, then, was to systematically explore effects of using word processing technology for writing on the complex cognitive processes of writers. In this endeavor we were guided by a particular way of looking at writing: a cognitive process theory of writing. All research, we believe, is driven by theory. However, some of the early work in the area of computers and writing failed to specify and articulate the theories of the researchers. In educational research particularly, clearly articulated theories of writing are of critical importance, both to judge the merits of the research itself and to determine its applicability to other problems and situations.

The theory which guided our approach to assessing the effects of word processing on writing draws on the theoretical work of cognitive process researchers in writing, such as John R. Hayes and Linda Flower at the Center for the Study of Writing (Flower & Hayes, 1981; Hayes, Flower, Schriver, Stratman, & Carey, 1987; Flower, Schriver, Carey, Haas, & Hayes, 1989) and Marlene Scardamalia and Carl Bereiter at the Ontario Institute for Studies in Education (Bereiter & Scardamalia, 1987), among others. This cognitive process theory of writing holds that writing is a complex mental act, difficult to accomplish, to learn, and to analyze. Briefly stated, the tenets of the theory are:

- Writing is a cognitive act, an act of mind. Of course, writing is--or can be--an act of other kinds as well: social, political, physical, emotional. But a critical distinguishing feature of writing is that it is a cognitive act, in which one writer (or a group of writers) draws upon the exigencies of the situation, her own experiences and beliefs, the expectations of her group and culture, and the resources available to her to make a purposeful, verbal statement.
- Writing is a decision-making process. Writers make important choices as they write to accomplish their purposes. They decide if and when to write at all; they choose to address certain issues, problems, and audiences; they decide on appropriate tone, and wording, and voice. In this way, writing can be seen as an important and complex "problem," which a writer addresses by the choices he or she makes. These choices are guided by writers' own knowledge and purposes, of course, but they are also guided by a number of other critical factors.
- A number of critical factors can impact on the decisions a writer makes in the course of writing. Writing does not happen in a vacuum: writers' cultural, social, and physical environments shape writing in important ways. Among the environmental factors shaping writing is the technology writers have available.
- Writing can--although it may not always--be a way to form new conceptual knowledge. One of the reasons why educators are interested in writing is that very often writing involves the kind of complex thinking and conceptual reformulation that leads to "discovery," new insights, and conceptual learning.

These tenets of a cognitive process theory of writing have been very important in guiding our work assessing the effects of word processing on writing.

## 3.2. The context of the assessment

Specification and articulation of the setting of research is also important to judge the merits and applicability of the findings. Like all educational assessments, ours took place in a particular time and place, with particular writers and writing technologies. The site was a medium-sized private university in the midwest. The university has a strong reputation both in engineering and technology and in the fine arts.

Two distinct groups of writers within this setting participated in our research. For several of the studies, groups of second-semester freshman students were randomly selected for participation. The second group of writers were experienced, published writers--some academics, some graduate students, some teachers, and some professional writers.

All participants were experienced with the computer and word processor used in the studies. Most of the experienced writers used the technology on a daily basis, and the students had completed both an introductory workshop using the computer technology and a computer writing course using the word processor. In addition, each subject completed a "pre-test" of facility with the computer and word processing technology used in the study in which he or she was participating. (Haas, 1987, contains the most complete account of this pre-test and other controls for computer experience.)

The computer system used in the studies was the "Andrew" system, developed by IBM and Carnegie Mellon University at the Information Technology Center (Morris, et al, 1986). Individual workstations contain hard disks and are linked together via a network. The word processor, "EditText" (and a similar subsequent version renamed "EZ") was also developed at the Information Technology Center and was based on EMACS.

Both the Andrew workstation and EditText have a number of features particularly beneficial for writers. The workstation is equipped with a large, 19-inch, high-resolution bit-mapped display. Users can see several "windows" at once; for instance, a writer could simultaneously view several documents or versions of documents. The workstation also has a mouse, and the same commands can be with the mouse and menus, or by using the keyboard.

The EditText editor utilizes the large display and windowing capabilities of the Andrew system. In addition, variable fonts and styles are available. Writers move through documents using either keystrokes or mouse and scrollbar, which indicates graphically the size of the document and the current position in the document. The editor also contains a "preview" program to view an image of the printed page without printing.

While this computer system is somewhat more advanced than many currently available word processors, we argued in the original proposal that it made sense to use it for our assessment because this technology gives word processing the "best chance" to realize its potential benefits and it will be the technology that the most writers who use word processing will have available in the coming decade.

# 4. Project description

Our original goal for the project was a of series studies, focusing on three subprocesses of writing: planning, reviewing, and revising. While some of the studies in the original proposal changed, the final six studies we conducted did address these three areas:

- **Planning**

  *Study 1. How Word Processing Affects Planning.* Examined planning process of experiences and student writers in three conditions, word processing alone, pen and paper, and word processing and pen and paper; a study from the original proposal.

  *Study 2. Connecting Process and Product: A Study of Planning Processes, Text Quality, and Writing Media.* Examined the complex relationship between writing media, planning processes, and judged quality of the content and organization of the resulting essays; a study from the original proposal.

  *Study 3. Composing in Technological Contexts: A Study of Note-Making.* An in-depth analysis of note-making in writing and a comparison of this activity across pen and paper and word processing conditions; a study added in Year 3.

- **Reviewing**

  *Study 4. A Naturalistic Study of Computer Writers' Reading Problems* Tracked six freshmen and five adult writers for the course of four months and examined the kinds of reading problems they had when using computers and how they used hard copy to supplement computer writing; a study from the original proposal.

  *Study 5. A Sense of the Text: Problems Writers Encounter in Building Text Representations.* Examined how well writers understood their own texts, written with pen and paper or with word processing; also related this "sense of text" to planning processes; a study added in Year 2.

- **Revision**

  *Study 6. Understanding On-line Revision.* Using as a prototype the seminal Hayes, et al., study (1987), this study examined revising behaviors of expert and student writers in two conditions; a study from the original proposal.

This final set of studies reflects several changes from our original proposal. Our original plans changed for a number of reasons. First, as the project proceeded, we learned a great deal and consequently chose to pursue some new lines of inquiry. For instance, in conducting Study 4 ("A Naturalistic Study of Computer Writers' Reading Problems"), we were able to describe the "text sense" problem more completely; this made Study 5, which looked in more detail at this problem, possible. Second, the analysis of some of the data was more complicated than we had originally anticipated, and we chose to look at some of the writers and writing in more detail, rather than collecting more data and treating it superficially. This was the case in Studies 2 and 3: in conducting Study 1, we became convinced of the importance of planning--and the critical role that technological contexts may play in writers' planning--and we were led back to the rich protocol and textual data generated in this study for use in Studies 2 and 3 ("Connecting process and product: A study of planning processes, text quality, and writing media" and "Composing in Technological Contexts: A Study of Note-Making").

Focusing our studies in this way limited both the number of studies we could conduct and the questions we could pursue. However, we felt, given the complexity of both the technology's effects on composing and the educational policy questions at issue, that a deeper understanding of a few key aspects of composing would in the long run be more satisfying and more valuable.

# 5. Outcomes and results

## 5.1. Results of the studies

*Study 1. How Word Processing Affects Planning.* Writers using word processing alone engaged in significantly less total planning, initial planning, and conceptual planning than when they used pen and paper. The effects were similar for both student writers and more experienced professional writers. A third condition, in which writers used both media, showed no clear effects: writers used both media together in vastly different and very complex ways. (Study completed in Year 2.)

*Study 2. Connecting Process and Product: A Study of Planning Processes, Text Quality, and Writing Media.* Our original plans included an analysis of quality for the essays produced in the three conditions in Study 1. This analysis was carried out, but as we thought more about the issues underlying our comparison of texts, we expanded the analysis to include a process component as well as the assessment of the written product. Our thinking went like this: when we as educators expect quality differences in essays composed with computers and with pen and paper, we are making assumptions about quality which often remain only implicit. That is, we don't expect that there is something inherent in a word processor that allow writers to produce better essays as if by magic. What we do expect, if we indeed expect an advantage for computer-written essays, is that the writing media will somehow facilitate or change the process by which writing is produced, therefore resulting in "better" writing.

Therefore, our design of this study changed somewhat. In addition to a comparison of the essays written in pen and paper and word processing conditions, we built in a second analysis in which we related product quality to writing process. Specifically, planning--seen by many theorists and educators as critical to writing success--was related to resulting quality scores.

Twenty writers wrote essays in three conditions: pen and paper, word processing and word processing with pen and paper allowed, resulting in a total of 60 essays. These essays were judged by experienced teachers of writing within subjects; that is, each writer's essays were compared only to his or her other essays and within each set of three essays by one writer, judges placed each on a scale of 1 to 3. Three measures of quality were used: content quality, organizational quality, and combined quality. In each case--content, organization, and combined--scores of pen essays were slightly higher than word processing essays (means= 2.1 and 1.7, 2.2 and 1.7, and 2.1 and 1.8, respectively) with the condition using both word processing and pen and paper falling in the middle. However, these scores were far from significant.

In the second phase of our analysis, four measures of planning (for which significant results had been obtained in Study 1, above; see Haas, 1989b) were selected for comparison with quality ranking: total planning, initial planning, conceptual planning, and local planning. This analysis focused on the pen and word processor conditions as the two extreme conditions--both in planning and in quality--established with the prior analyses. Therefore, eight separate analyses examined the relationship of the four kinds of planning--total, initial, conceptual, and local--with the two measures of quality: organization quality and combined quality. (Content quality was not included because of low reliability on this measure.)

Analysis revealed that two measures of planning showed no relationships with quality, while two did. Initial planning--planning before beginning to write--had no significant relationship with either measure of quality. Local planning--at the word- and sentence-level--similarly had no relationship (positive or negative) with text quality.

However, total amount of planning was significantly related to organizational quality, although the relationship of total planning to combined quality was not significant. The most significant relationships were found with conceptual planning, however. This kind of planning showed a significant relationship with organizational quality and was also related to combined quality scores. Table 2-1, below, summarizes the results of this second part of the analysis.

**Table 5-1:** Significant relationships between planning and quality*

| | **Quality** | |
|---|---|---|
| | *Organization* | *Combined* |
| **Planning** | | |
| *Total* | $p<.05$ | NS |
| *Initial* | NS | NS |
| *Conceptual* | $p<.01$ | $p<.05$ |
| *Local* | NS | NS |

*Using contingency coefficient C, N = 19

These results, while tentative (given the small number of subjects), offer an encouraging start in understanding how process and product differences are related. The results are encouraging, for they reinforce what teachers and researchers believe: that planning is important and beneficial, that it has some relationship with the written text, that conceptual, high-level thinking during writing is valuable, even critical, for written composition.

Again, these results do *not* suggest that there are important quality differences for writing done on a word processor. However, as computer technology becomes more useful for writing and more suitable for teaching writing--particularly in the support of planning--there is every reason to suppose that essays produced with computers, *if* they were also planned extensively, could be higher in quality. (Study completed in Year 3.)

*Study 3. Composing in Technological Contexts: A Study of Note-Making.* This study used both descriptive and experimental methods to examine the kind of planning notes made by experienced writers

composing with pen and paper and with word processing. The study defined a range of note-making strategies that writers can use, regardless of writing medium, and found that these nine writers primarily made four kinds of notes: content notes, by far the most prevalent; structure notes, also common, in which writers made outlines or otherwise structured their ideas; emphasis notes, less frequent, in which writers highlighted or emphasized certain ideas; and procedural notes, quite rare, in which writers made notes to themselves about how to proceed.

By contrasting the same writers' note-making in pen and paper and word processing conditions, we were able to see differences in the kinds of notes writers make with pen and paper and with word processing. With word processing, writers tended to make content notes only, while with pen and paper they made a range of kinds of notes. Detailed analysis of individual writers' note-making showed that kind and the complexity of notes was influenced by the writing medium. For some writers, notes made with word processor were much more text-like than note-like. Based on theories of composing and transcribing, and on this analysis of note-making, the study also speculates on the way that current word processing technology may influence both writers' strategies and the approach they take to writing tasks. (Study completed in Year 3.)

*Study 4. A Naturalistic Study of Computer Writers' Reading Problems.* This study used observational methods to study how computer writers use "hard copy" printouts of their texts. Eleven case study subjects were observed for four months. We found that writers use printouts primarily for reading, specifically, for four reading purposes: to check format, to proofread, to reorganize, and to gain "a sense of the text." There were differences across groups of writers, with student writers being more concerned with format and proofreading and experienced writers reading for all four purposes. Further, longer and more difficult tasks elicited more reading to reorganize and reading to gain a sense of the text. (Study completed in Year 1).

*Study 5. A Sense of the Text: Problems Writers Encounter in Building Text Representations.* This study continued the examination of a problem that we began in Haas & Hayes (1986) and Study 3, above. In our interviews with numerous computer writers and in our study of computer writers' reading problems we frequently encountered what writers themselves often called "a problem getting a sense of the text." When using word processing, these writers spoke of often feeling confusion about the shape and form of their own emerging texts. Typically, writers would print their texts to alleviate this problem. Some writers said that they often couldn't even judge the merits of their texts until they saw them printed out. This problem seemed to go beyond a necessity to read-to-revise: many of the writers simply felt they didn't "know" their texts as well when they composed them on-line.

Our earlier efforts to explore this problem centered on examining display variables of computers that might cause, or alleviate, the problem (Haas & Hayes, 1986; Hansen & Haas, 1988), or on exploring writer or task differences that might effect it (Haas, 1989a). The current study examined the existence of the phenomenon itself, by testing whether writers do indeed "know" their texts less well, or have less of a "sense of text," when composing on-line.

Ten experienced writers composed essays in pen and paper conditions. Two weeks after the initial writing session, writers were again shown the materials they had used in the writing (topic, instructions) and asked to recall "in as much detail as possible" the main points of their essays in order. Writers attempted to recall both essays they had written, in the order in which they had originally created them. Measures were taken of the time it took writers to recall their texts, as well as the accuracy of the recalls.

There were no differences in the time it took writers to recall the texts written with different media, but there were significant differences in the accuracy scores: writers recalled more of the main points of their essays when they were composing with pen and paper. In order to partially explain these results, we related writers' planning times (as measured in clauses of think-aloud protocols) to their text recall scores and found that those texts which writers planned most extensively were also recalled in greater detail. In this way, we begin to see a relationship between what previously had seemed to be disparate problems: repressed planning with word processing, and the text sense problem.

These results strongly suggest that the "text sense" problem that writers report when using word processing has some psychological reality. It also suggests that writers use of paper to supplement their computer writing is not simply a habit left-over from pre-computer training--as some authors have speculated--but that it meets a real need that writers have to gain a sense of their own texts. (Study completed in Year 3.)

*Study 6. Understanding On-line Revision.* This study used as a prototype the 1987 Hayes, Flower, Schriver, Stratman, and Carey study of revision, partially replicating the earlier study--in comparing two groups of writers' revision behavior--but also examined differences in revising for the same writers using writing media (pen and paper or word processor). Sixteen writers, eight from each group, participated in the study. In each condition, writers revised a somewhat disorganized and informal letter into a pamphlet or brochure to be used by a specific audience. The task required writers to attend to local problems in the text, as well as larger concerns such as tone, contradictory or missing information, and suitability to the audience.

Analysis of the resulting think-aloud protocols and texts focused on 1), Task Definition, or the writers' knowledge about and conception of the problem of revision that lies before them; 2), Levels of Problem Representation, or the kind of problem--global or local--upon which the writers focused; 3), the Detection and Correction of Errors, or the number of planted errors that writers explicitly mentioned and/or corrected during their revising sessions.

Results in general corroborated the findings of Hayes et al. in terms of expert-novice differences. The experienced writers focused on more global concerns in their revising than did the students, whose comments and revisions tended to cluster at the local level. The experienced writers also found and corrected more errors than did the students, and although the students mentioned more of the errors, the experienced writers corrected more of them.

Interestingly, there were no effects for writing medium--pen and paper or word processor--in any of the analyses. In general, the experienced writers behaved like experienced writers and the students, like students, regardless of condition. In measures of task definition, problem representation, and detection and correction of errors, the medium in which writers were working made little difference.

While an effect of "no difference" is not particularly compelling, in this case it is very important. What this means is that we cannot expect that the word processor alone will make an appreciable difference in how writers revise. Sitting students down in front of computers and expecting their revision habits to change is simply not realistic. The complexity of revision, the importance of what a writer wants to accomplish revision, the writer's goals for both the text and for the revision process--tenets of our theories of revision (Hayes, et al, 1987; Scardamalia & Bereiter, 1983)--are reinforced by the results of this study. If we wish to change our students' revision behaviors, then changing their conceptions of and goals for revision must accompany any changes in their writing tools. (Study completed in Year 3.)

## 5.2. Changes in our conception of the problem

In addition to the results of the studies themselves, some of the most important results of our project were changes in our own thinking about the question of how word processors affect writing. First, doing the project sharpened our ability to tease out differences and relationships. For instance, unpacking common assumptions about quality in writing led us to redesign our analysis of Study 2 to include a process component, and further, to reformulate our thinking on the complex relationship of writing quality and writing process.

The project also changed our thinking in another, somewhat different way: it helped us to see relationships between problems that we had thought disparate. In studying what had seemed at the outset to be the separate problems of planning, text sense, and writing quality, we came to see that these components of writing are in fact intrinsically related. So, two of the final studies that we completed (Studies 2 and 5) crossed some of the "boundaries" that we had mistakenly set up between aspects of the problem. While it is often beneficial to divide problems, we also realized a need to step back and see how seemingly separate problems are really related.

Finally, the project helped to reaffirm and support some of our previous assumptions about writing and technology:

- that planning is a critical and wide-ranging process of writing
- that technology does and will have effect--both for good and for ill--on writing
- that awareness of those effects can allow us to channel them
- that the most important variables in successful writing (in terms either of quality or of learning) may not be technological, but more complicated--and more difficult to control--things like goals, and context, and knowledge.

## 5.3. Educational implications

We believe that our project has important educational implications and our work has already begun to make an impact on how computers are used in writing education. Four of the most important implications are these:

1. Writers use word processors in complex and varied ways. Our computer writing pedagogy should allow a range of ways to use the technology. It should even encourage various ways of using technology as a way to continue to learn how word processing--and other, newer technologies--support or inhibit writing (Studies 1, 2, 3, 5).

2. While acknowledging that various approaches to using word processing should be encouraged, we also believe that students may need guidance in using technology to its full advantage. Students should be encouraged to print their texts often and to use these printouts for review; they should also be discouraged from focusing too narrowly on the kind of surface level thinking that is so greatly facilitated by the machine. In addition, teachers should provide explicit (and possibly visual and graphic) support for the critical act of planning throughout the writing process. Further, teachers should encourage their students to be good observers of themselves and their writing styles, becoming aware of and pointing out to others where the technology particularly helps or hinders them (Studies 1, 3, 4, and 6)

3. Technology alone cannot and should not be expected to make significant improvements in students' writing processes or written products. Dedicated teachers, informed pedagogy, relevant and accessible instruction--these may, with the best technological supports, change students' conceptions of writing, their feelings about it, and their skill at accomplishing it. Word processing alone cannot (Studies 2, 4, and 6).

4. Computer technology for writers should be improved. Our project has revealed a number of ways that existing word processing technology causes writers problems--in viewing their texts globally, in planning their content and structure, in critically judging them. However, these problems are not inherent in the technology: word processing is a tool, developed for human use, which can be changed and adapted to meet the needs of those it is designed to serve. We believe that educators, experienced with computer technology, are in an ideal position to judge, criticize, and provide feedback on how existing writing tools can be improved and we encourage all educators to be vocal and responsible consumers of technology (Studies 1, 2, 3, and 5).

## 5.4. Impact and dissemination

Our results have been incorporated into the curriculum at Carnegie Mellon and we have worked to disseminate those results and encourage their incorporation at other schools as well.

### 5.4.1. Courses and workshops

All undergraduates at CMU are required to take a designated writing course; most students take it as freshmen. Most of the teachers of that course, Ph.D. in rhetoric students, study the research reported here and its educational implications in a required graduate course and are encouraged to apply those findings in their own teaching practice.

Last year, we presented a day long workshop at *College Composition and Communication, CCCC* which represented the results of our project and asked participants to work toward incorporating them into their own curriculums. This workshop was sponsored by the *CCCC Committee on Computers and Composition*. The Committee sponsors one each year. Chris Neuwirth is a member of the committee, and although she is not conducting the workshop this year, she has requested that the results be made available to participants again. The workshop materials are also available as a CMU-CECE Technical Report.

### 5.4.2. Technical reports

CMU-CECE-TR-4 *Word Processing as Decision-making: Writers' Choices of Writing Media.*

CMU-CECE-TR-5 *"Seeing it on the Screen Isn't Really Seeing It": Reading Problems of Writers Using Word Processing.*

CMU-CECE-TR-6 *How the Writing Medium Shapes the Writing Process: Effects of Word Processing on Planning.*

CMU-CECE-TR-9 *Understanding On-line Composition: Applying a Cognitive Model of Revision to Word Processing.*

CMU-CECE-TR-10 *Composing in Technological Contexts: A Study of Note-Making.*

CMU-CECE-TR-11 *A Sense of the Text: Problems Writers Encounter in Building Text Representations.*

CMU-CECE-TR-12 *Theory and Research into Practice: Word Processing and Writing Instruction.*

### 5.4.3. Conference Presentations

Presentations by Haas based on FIPSE-supported work included: "A Sense of the Text: The Role of the Emerging Text in the Composing Process," presented at the Conference on College Composition and Communication in March, 1989; "What is the Potential of the Word Processor as a Composing Tool? A Study of Planning," presented at the American Educational Research Association Annual Meeting in April, 1989; and "A Sense of One's Own Text: Problems Writers Encounter in Building Text Representations," presented at the National Reading Conference in November, 1988. A presentation based on Study 6, "Understanding On-Line Revision," was also presented at the American Educational Research Association Annual Meeting in April, 1989 by Charles Hill and David Wallace.

### 5.4.4. Publications

Publications by Haas of FIPSE-supported work included: "How the Writing Medium Shapes the Writing Process: Effects of Word Processing on Planning," which appeared in Research in the Teaching of English in May, 1989, and "'Seeing it on the Screen Isn't Really Seeing It': Computer Writers' Reading Problems," in Gail Hawisher and Cynthia Selfe (Eds.), Critical Perspectives on Computers and Composition Instruction, published by Teachers College Press. An article based on Study 3 ("Composing in Technological Contexts: A Study of Note-Making") has also been submitted to Written Communication.

### 5.4.5. Tool design

We are working to incorporate results into the design of new writing tools (Neuwirth & Kaufer, 1989).

## 6. Summary and conclusions

As a result of our studies, we believe that teachers should take active steps to insure that their students learn to use word processing effectively in composing. In particular, writing teachers with students who use word processing to compose should see that students:

- Plan with a combination of pen and paper and word processing, not word processing alone, or compensate for reduced planning with word processing alone by using an appropriate planning tool that prompts planning (Kozma, in press).
- Get frequent print-outs of drafts. A "paperless" writing curriculum should not be encouraged.

These recommendations have implications for administrators, who must insure that students have adequate access to printing facilities.

# 7. References

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# 8. Appendix

1. What forms of assistance from FIPSE were helpful to you? How can FIPSE more effectively work with projects?

At the beginning of the project, FIPSE asked us to hold a symposium on the effects of word processing in which we invited other researchers to present their current work and to discuss and critique the plans for our work. We found this useful. In other grants, we have had similar "advisory boards" of experts and have generally found it useful to meet once a year to review progress and critique plans.

Also of value was FIPSE's role in putting us in touch with other FIPSE-funded projects doing related work.

2. What should the FIPSE staff consider in reviewing future proposals in your area of interest? What are emerging new directions? What are key considerations, given your type of project?

Three directions are emerging in the use of computers in composition tools: the composition of non-linear texts (i.e., hypertexts or hypermedia), the use of hypermedia to support writing processes, and the use of computer networks in the teaching of writing. The key consideration in any assessment of these tools is that the researchers base the assessment on a theory of cognitive and social consequences of these tools.